Machine Poetize

December 9, 2024

0.1 Data Import

[1]:
```
# If the 'datasets' package is not installed, remove the comment symbol below␣
 ↪to install it
# !pip install datasets
from datasets import load_dataset

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import re

import tensorflow as tf
from tensorflow.keras.preprocessing.text import Tokenizer
from tensorflow.keras import backend as K
from tensorflow.keras.models import Model
from tensorflow.keras.layers import Input, Embedding, Dense, Activation,␣
 ↪Flatten, SimpleRNN, LSTM, Dropout
from sklearn.model_selection import train_test_split
from tensorflow.keras.utils import to_categorical, Sequence
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.preprocessing.sequence import pad_sequences
from sklearn.model_selection import train_test_split

from collections import Counter
```

```
/root/miniconda3/envs/myconda/lib/python3.10/site-packages/tqdm/auto.py:21:
TqdmWarning: IProgress not found. Please update jupyter and ipywidgets. See
https://ipywidgets.readthedocs.io/en/stable/user_install.html
  from .autonotebook import tqdm as notebook_tqdm
2024-12-09 21:30:14.025971: I tensorflow/core/util/port.cc:110] oneDNN custom
operations are on. You may see slightly different numerical results due to
floating-point round-off errors from different computation orders. To turn them
off, set the environment variable `TF_ENABLE_ONEDNN_OPTS=0`.
2024-12-09 21:30:14.080288: I tensorflow/core/platform/cpu_feature_guard.cc:182]
This TensorFlow binary is optimized to use available CPU instructions in
performance-critical operations.
To enable the following instructions: AVX2 AVX512F AVX512_VNNI FMA, in other
```

```
operations, rebuild TensorFlow with the appropriate compiler flags.
2024-12-09 21:30:14.978000: W
tensorflow/compiler/tf2tensorrt/utils/py_utils.cc:38] TF-TRT Warning: Could not
find TensorRT
```

[2]:
```
# Try to connect to Hugging Face and load the dataset
# ds = load_dataset("larryvrh/Chinese-Poems")
# print(ds)
```

[3]:
```
# If the connection fails, use a local dataset
dataset_path = "/root/train-00000-of-00001.parquet"
ds = load_dataset("parquet", data_files=dataset_path)

print(ds)
```

```
DatasetDict({
    train: Dataset({
        features: ['dynasty', 'author', 'title', 'content'],
        num_rows: 217561
    })
})
```

0.2 Data Understanding

[4]:
```
# Check the dataset statistics
stats = {
    "Number of Rows": len(ds['train']),
    "Number of Columns": len(ds['train'].column_names),
    "Columns": ds['train'].column_names,
    "Sample Data": ds['train'][:5]
}

# Assess data quality (null or empty values)
empty_values = {
    column: sum(1 for value in ds['train'][column] if not value.strip())
    for column in ds['train'].column_names
}

# Unique values in the 'dynasty' column
dynasty_stats = {
    "Unique Dynasties": len(set(ds['train']['dynasty'])),
    "Dynasty Distribution": {dynasty: ds['train']['dynasty'].count(dynasty) for␣
 ↪dynasty in set(ds['train']['dynasty'])}
}

# Dataset Insights
sample_lengths = {
    "Content Lengths": [len(item) for item in ds['train']['content'][:5]],
```

```
    "Longest Content Length": max(len(item) for item in ds['train']['content']),
    "Shortest Content Length": min(len(item) for item in␣
 ↪ds['train']['content']),
}
```

[5]:
```
print("Dataset Statistics:", stats)
print("Empty Values:", empty_values)
print("Dynasty Stats:", dynasty_stats)
print("Content Length Insights:", sample_lengths)
```

```
Dataset Statistics: {'Number of Rows': 217561, 'Number of Columns': 4,
'Columns': ['dynasty', 'author', 'title', 'content'], 'Sample Data': {'dynasty':
[' ', ' ', ' ', ' ', ' '], 'author': [' ', ' ', ' ', ' ', ' '],
'title': ['   ', ' ', '       ', '   ', '  '], 'content':
['        \n        ', '        \n        ',
'        \n        ',
'                        ',
'      \n      ']}}
Empty Values: {'dynasty': 0, 'author': 0, 'title': 1, 'content': 0}
Dynasty Stats: {'Unique Dynasties': 16, 'Dynasty Distribution': {' ': 9714,
' ': 34527, ' ': 17661, ' ': 7997, ' ': 104244, ' ': 173, ' ': 32014,
' ': 5601, ' ': 1163, ' ': 462, ' ': 123, ' ': 2292, ' ': 319, ' ': 107,
' ': 198, ' ': 966}}
Content Length Insights: {'Content Lengths': [33, 33, 33, 48, 25], 'Longest
Content Length': 20111, 'Shortest Content Length': 5}
```

[6]:
```
# Categorize poems based on their lengths
categories = {
    "100-200": [poem for poem in ds['train'] if 100 < len(poem['content']) <=␣
 ↪200],
    "200-500": [poem for poem in ds['train'] if 200 < len(poem['content']) <=␣
 ↪500],
    "500-1000": [poem for poem in ds['train'] if 500 < len(poem['content']) <=␣
 ↪1000],
    ">1000": [poem for poem in ds['train'] if len(poem['content']) > 1000],
}

# Count the number of poems in each category
category_counts = {key: len(value) for key, value in categories.items()}

# Create a DataFrame for display
category_df = pd.DataFrame.from_dict(category_counts, orient='index',␣
 ↪columns=['Number of Poems'])
category_df.index.name = "Length Range"

# Display the result
print(category_df)
```

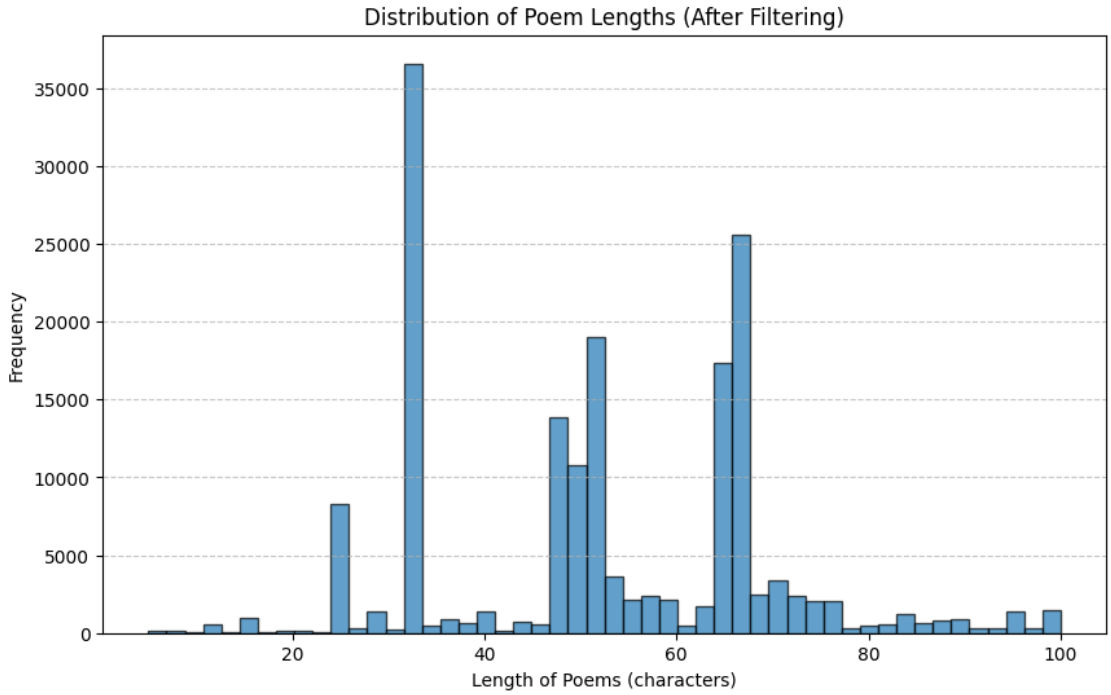
```
              Number of Poems
Length Range
100-200                 36456
200-500                  5751
500-1000                  685
>1000                     298
```

[7]:
```
# Filter out poems where the title is empty and poems where the content length␣
↪is greater than 200
filtered_poems = [
    poem for poem in ds['train'] if poem['title'].strip() and␣
↪len(poem['content']) <= 100
]

# Convert the filtered poems to a DataFrame for display
filtered_poems_df = pd.DataFrame(filtered_poems)
```

[8]:
```
# Calculate the lengths of the filtered poems
filtered_lengths = [len(poem['content']) for poem in filtered_poems]

# Plot the histogram
plt.figure(figsize=(10, 6))
plt.hist(filtered_lengths, bins=50, edgecolor='black', alpha=0.7)
plt.title('Distribution of Poem Lengths (After Filtering)')
plt.xlabel('Length of Poems (characters)')
plt.ylabel('Frequency')
plt.grid(axis='y', linestyle='--', alpha=0.7)
plt.show()
```



0.3 STEP 1: LOGIT

[9]:
```
modified_poems = [
    {"content": "aaa" + re.sub(r"[^\w\s]", "", poem['content']).replace("\n",␣
 ↪"").strip()}
    for poem in filtered_poems
]

# Print the modified data for the first few rows
for i in range(3):
    print(modified_poems[i])

# Convert to DataFrame for better display or further processing
modified_poems_df = pd.DataFrame(modified_poems)

# Display the first few rows of the DataFrame
print(modified_poems_df.head())
```

```
{'content': 'aaa                '}
{'content': 'aaa                '}
{'content': 'aaa                '}
                                content
0               aaa
1               aaa
2               aaa
```

```
3  aaa
4                      aaa
```

[10]:
```
# If the training memory is insufficient, you can uncomment the following code to reduce the training data.
import random
modified_poems = random.sample(modified_poems, len(modified_poems) // 2)
```

[11]:
```
XY = []

# Iterate through the processed poem content
for poem in modified_poems:
    content = poem['content']
    for i in range(len(content) - 3):
        x1 = content[i]
        x2 = content[i + 1]
        x3 = content[i + 2]
        y = content[i + 3]
        XY.append([x1, x2, x3, y])

# Print sample data
print("Training_data:")
print(["X1", "X2", "X3", "Y"])
for i in range(10):
    print(XY[i])
```

```
Training_data:
['X1', 'X2', 'X3', 'Y']
['a', 'a', 'a', ' ']
['a', 'a', ' ', ' ']
['a', ' ', ' ', ' ']
[' ', ' ', ' ', ' ']
[' ', ' ', ' ', ' ']
[' ', ' ', ' ', ' ']
[' ', ' ', ' ', ' ']
[' ', ' ', ' ', ' ']
[' ', ' ', ' ', ' ']
[' ', ' ', ' ', ' ']
```

[12]:
```
# Prepare data (Assuming XY is the previously generated sliding window data)
# XY is in the format [["X1", "X2", "X3", "Y"], ...]
text_data = ["".join(item) for item in XY]

# Initialize Tokenizer
tokenizer = Tokenizer(char_level=True)  # Set char_level=True to process at the character level
tokenizer.fit_on_texts(text_data)
```

```
# Print the vocabulary
# print("Vocabulary:")
# print(tokenizer.word_index)

# Calculate the vocabulary size
vocab_size = len(tokenizer.word_index) + 1
print("\n vocab size:", vocab_size)

# Encode XY into digits
XY_digit = np.array(tokenizer.texts_to_sequences(text_data))
X_digit = XY_digit[:, :3]
Y_digit = XY_digit[:, 3]

# Print sample data
print("\n sample data:")
for i in range(10):
    print(f"{str(X_digit[i]):<30}\t{Y_digit[i]}")
```

```
 vocab size: 9137

 sample data:
[1 1 1]                         706
[  1   1 706]                   3034
[   1  706 3034]                490
[ 706 3034  490]                6501
[3034  490 6501]                1884
[ 490 6501 1884]                1941
[6501 1884 1941]                249
[1884 1941  249]                126
[1941  249  126]                1175
[ 249  126 1175]                6
```

[13]:
```
# Count word frequencies and keep high-frequency words
word_counts = Counter(Y_digit)
filtered_words = {word: idx for idx, (word, count) in enumerate(word_counts.
 ↪items()) if count >= 100}

# Update Y_digit and calculate the new vocab_size
Y_digit = [word for word in Y_digit if word in filtered_words]
vocab_size = len(filtered_words) + 1
# num_classes = max(Y_digit) + 1
```

[14]:
```
# Clear GPU memory
K.clear_session()
tf.config.experimental.reset_memory_stats('/GPU:0')
```

```
2024-12-09 21:31:44.699587: I
```

```
tensorflow/core/common_runtime/gpu/gpu_device.cc:1639] Created device
/job:localhost/replica:0/task:0/device:GPU:0 with 78933 MB memory:  -> device:
0, name: NVIDIA A100 80GB PCIe, pci bus id: 0000:15:00.0, compute capability:
8.0
```

[15]:
```
filtered_indices = [i for i, idx in enumerate(Y_digit) if idx < vocab_size]

X_digit = [X_digit[i] for i in filtered_indices]
Y_digit = [Y_digit[i] for i in filtered_indices]

# Check lengths again
print("Filtered Length of X_digit:", len(X_digit))
print("Filtered Length of Y_digit:", len(Y_digit))
```

```
Filtered Length of X_digit: 3668475
Filtered Length of Y_digit: 3668475
```

[16]:
```
hidden_size = 256

# Define the input layer
inp = Input(shape=(3,))
x = Embedding(vocab_size, hidden_size)(inp)
x = Flatten()(x)
x = Dense(vocab_size, activation='softmax')(x)  # Add softmax here
pred = x


# Define the model
model = Model(inp, pred)
model.summary()

# Compile the model
model.compile(
    loss='categorical_crossentropy',
    optimizer=Adam(learning_rate=0.001),
    metrics=['accuracy']
)

# Define the generator class
class DataGenerator(Sequence):
    def __init__(self, X, Y, batch_size, num_classes):
        self.X = np.array(X)
        self.Y = np.array(Y)
        self.batch_size = batch_size
        self.num_classes = num_classes
        self.indices = np.arange(len(self.X))

    def __len__(self):
```

```
        return int(np.ceil(len(self.X) / self.batch_size))

    def __getitem__(self, index):
        start = index * self.batch_size
        end = start + self.batch_size
        batch_indices = self.indices[start:end]

        X_batch = self.X[batch_indices]
        Y_batch = self.Y[batch_indices]

        Y_batch_onehot = to_categorical(Y_batch, num_classes=self.num_classes)
        return X_batch, Y_batch_onehot

# Prepare data
num_classes = vocab_size

# Split the data into training and test sets
X_train, X_test, Y_train, Y_test = train_test_split(
    X_digit, Y_digit, test_size=0.2, random_state=0
)

batch_size = 1024
train_generator = DataGenerator(X_train, Y_train, batch_size, num_classes)
test_generator = DataGenerator(X_test, Y_test, batch_size, num_classes)

# Train the model
model.fit(
    train_generator,
    validation_data=test_generator,
    epochs=20
)
```

```
Model: "model"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_1 (InputLayer)        [(None, 3)]               0

 embedding (Embedding)       (None, 3, 256)            727808

 flatten (Flatten)           (None, 768)               0

 dense (Dense)               (None, 2843)              2186267

=================================================================
Total params: 2914075 (11.12 MB)
Trainable params: 2914075 (11.12 MB)
Non-trainable params: 0 (0.00 Byte)
```

```
----------------------------------------------------------------
Epoch 1/20

2024-12-09 21:31:55.546393: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_blas.cc:606] TensorFloat-32
will be used for the matrix multiplication. This will only be logged once.
2024-12-09 21:31:55.551657: I tensorflow/compiler/xla/service/service.cc:168]
XLA service 0x7f6c2800eba0 initialized for platform CUDA (this does not
guarantee that XLA will be used). Devices:
2024-12-09 21:31:55.551723: I tensorflow/compiler/xla/service/service.cc:176]
StreamExecutor device (0): NVIDIA A100 80GB PCIe, Compute Capability 8.0
2024-12-09 21:31:55.566247: I
tensorflow/compiler/mlir/tensorflow/utils/dump_mlir_util.cc:255] disabling MLIR
crash reproducer, set env var `MLIR_CRASH_REPRODUCER_DIRECTORY` to enable.
2024-12-09 21:31:55.768242: I
tensorflow/compiler/xla/stream_executor/cuda/cuda_dnn.cc:432] Loaded cuDNN
version 8900
2024-12-09 21:31:55.952039: I ./tensorflow/compiler/jit/device_compiler.h:186]
Compiled cluster using XLA!  This line is logged at most once for the lifetime
of the process.

2866/2866 [==============================] - 67s 23ms/step - loss: 7.0797 -
accuracy: 0.0095 - val_loss: 7.0591 - val_accuracy: 0.0089
Epoch 2/20
2866/2866 [==============================] - 36s 13ms/step - loss: 7.0070 -
accuracy: 0.0103 - val_loss: 7.0798 - val_accuracy: 0.0090
Epoch 3/20
2866/2866 [==============================] - 34s 12ms/step - loss: 6.9069 -
accuracy: 0.0110 - val_loss: 7.1390 - val_accuracy: 0.0085
Epoch 4/20
2866/2866 [==============================] - 36s 13ms/step - loss: 6.8090 -
accuracy: 0.0115 - val_loss: 7.2123 - val_accuracy: 0.0083
Epoch 5/20
2866/2866 [==============================] - 36s 12ms/step - loss: 6.7355 -
accuracy: 0.0117 - val_loss: 7.2805 - val_accuracy: 0.0075
Epoch 6/20
2866/2866 [==============================] - 35s 12ms/step - loss: 6.6835 -
accuracy: 0.0119 - val_loss: 7.3381 - val_accuracy: 0.0075
Epoch 7/20
2866/2866 [==============================] - 37s 13ms/step - loss: 6.6463 -
accuracy: 0.0123 - val_loss: 7.3849 - val_accuracy: 0.0073
Epoch 8/20
2866/2866 [==============================] - 35s 12ms/step - loss: 6.6187 -
accuracy: 0.0127 - val_loss: 7.4228 - val_accuracy: 0.0068
Epoch 9/20
2866/2866 [==============================] - 36s 13ms/step - loss: 6.5973 -
accuracy: 0.0132 - val_loss: 7.4541 - val_accuracy: 0.0066
Epoch 10/20
2866/2866 [==============================] - 36s 13ms/step - loss: 6.5800 -
```

```
accuracy: 0.0136 - val_loss: 7.4811 - val_accuracy: 0.0067
Epoch 11/20
2866/2866 [==============================] - 35s 12ms/step - loss: 6.5658 -
accuracy: 0.0141 - val_loss: 7.5047 - val_accuracy: 0.0067
Epoch 12/20
2866/2866 [==============================] - 36s 13ms/step - loss: 6.5537 -
accuracy: 0.0144 - val_loss: 7.5255 - val_accuracy: 0.0065
Epoch 13/20
2866/2866 [==============================] - 35s 12ms/step - loss: 6.5431 -
accuracy: 0.0148 - val_loss: 7.5440 - val_accuracy: 0.0064
Epoch 14/20
2866/2866 [==============================] - 35s 12ms/step - loss: 6.5339 -
accuracy: 0.0151 - val_loss: 7.5616 - val_accuracy: 0.0062
Epoch 15/20
2866/2866 [==============================] - 36s 13ms/step - loss: 6.5257 -
accuracy: 0.0152 - val_loss: 7.5778 - val_accuracy: 0.0062
Epoch 16/20
2866/2866 [==============================] - 35s 12ms/step - loss: 6.5183 -
accuracy: 0.0156 - val_loss: 7.5925 - val_accuracy: 0.0061
Epoch 17/20
2866/2866 [==============================] - 36s 12ms/step - loss: 6.5116 -
accuracy: 0.0159 - val_loss: 7.6061 - val_accuracy: 0.0064
Epoch 18/20
2866/2866 [==============================] - 35s 12ms/step - loss: 6.5056 -
accuracy: 0.0159 - val_loss: 7.6201 - val_accuracy: 0.0064
Epoch 19/20
2866/2866 [==============================] - 36s 12ms/step - loss: 6.5001 -
accuracy: 0.0163 - val_loss: 7.6324 - val_accuracy: 0.0062
Epoch 20/20
2866/2866 [==============================] - 36s 12ms/step - loss: 6.4950 -
accuracy: 0.0164 - val_loss: 7.6447 - val_accuracy: 0.0061
```

[16]:
```
<keras.src.callbacks.History at 0x7f6dd8f4ebc0>
```

[17]:
```python
# Sample text, predict the next character
sample_text = [' ', ' ', ' ']
print("Sample text:", sample_text)

sample_index = tokenizer.texts_to_sequences(sample_text)
print("Index:", sample_index)

word_prob = model.predict(np.array(sample_index).reshape(1, 3))
predicted_index = word_prob.argmax()
predicted_word = tokenizer.index_word[predicted_index]

print("next word:", predicted_word, " max probability:", word_prob.max())
```

```
Sample text: [' ', ' ', ' ']
```

```
Index: [[620], [73], [46]]
1/1 [==============================] - 0s 89ms/step
next word:   max probability: 0.013467364
```

[18]:
```python
poem_incomplete = 'aaa **** **** **** ****'  # Incomplete poem
poem_index = []
poem_text = ''

for i in range(len(poem_incomplete)):
    current_word = poem_incomplete[i]
    if current_word != '*':
        index = tokenizer.word_index.get(current_word, 0)
    else:
        x = np.array(poem_index[-3:]).reshape(1, 3)
        y = model.predict(x)
        index = y.argmax()  # Find the index with the highest probability
        current_word = tokenizer.index_word.get(index, '')

    poem_index.append(index)
    poem_text += current_word

# Display the generated poem
poem_text = poem_text[3:]
print("Generated poem:")
print(poem_text[:5])
print(poem_text[5:10])
print(poem_text[10:15])
print(poem_text[15:20])
```

```
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 20ms/step
Generated poem:
```

0.4 STEP 2: RNN

[19]:
```
poems = filtered_poems_df['content'].tolist()
def remove_punctuation(text):
    return re.sub(r'[^\w\s]', '', text)

poems = [remove_punctuation(poem) for poem in poems]

tokenizer = Tokenizer()
tokenizer.fit_on_texts(poems)

poems_digit = tokenizer.texts_to_sequences(poems)
# vocab_size = len(tokenizer.word_index) + 1

# Pad the sequences to ensure uniform length (a maximum length can be set as␣
 ↪maxlen)
maxlen = 49
poems_padded = pad_sequences(poems_digit, maxlen=maxlen, padding='post')

print("Vocabulary size:", vocab_size)
```

```
Vocabulary size: 2843
```

[20]:
```
word_counts = Counter([word for poem in poems_digit for word in poem])
```

[21]:
```
# Pad filtered sequences (before DataGenerator)
# max_len = 49
# poems_padded = pad_sequences(filtered_sequences, maxlen=max_len,␣
 ↪padding='post')

# Align X and Y
X = poems_padded[:, :-1]  # First n-1 tokens as input
Y = poems_padded[:, 1:]   # Last n-1 tokens as target

# Convert Y to NumPy integer array
Y = np.array(Y, dtype=np.int32)  # Ensure Y is a NumPy array
print("Shape of X:", X.shape)
print("Shape of Y:", Y.shape)
```

```
Shape of X: (174371, 48)
Shape of Y: (174371, 48)
```

[22]:
```
# Clear GPU memory
K.clear_session()
tf.config.experimental.reset_memory_stats('/GPU:0')
```

[23]:
```
# Define spatial dimensions
embedding_size = 64
hidden_size = 128

class DataGenerator(Sequence):
    def __init__(self, X, Y, batch_size, vocab_size):
        self.X = X
        self.Y = Y
        self.batch_size = batch_size
        self.vocab_size = vocab_size
        self.indices = np.arange(len(self.X))

    def __len__(self):
        return int(np.ceil(len(self.X) / self.batch_size))

    def __getitem__(self, index):
        start = index * self.batch_size
        end = start + self.batch_size
        batch_indices = self.indices[start:end]

        X_batch = self.X[batch_indices]
        Y_batch = self.Y[batch_indices]
        Y_batch_onehot = np.array([self.to_onehot(y, self.vocab_size) for y in␣
 ↪Y_batch])
        return X_batch, Y_batch_onehot
    def to_onehot(self, y, vocab_size):
        #y = np.asarray(y, dtype=np.int32).flatten()
        one_hot = np.zeros((y.shape[0], vocab_size), dtype=np.float32)
        for i, token in enumerate(y):
            if 0 <= token < vocab_size:
                one_hot[i, token] = 1.0
        return one_hot

# Split training and validation sets
Y = np.array(Y, dtype=np.int32)
X_train, X_val, Y_train, Y_val = train_test_split(X, Y, test_size=0.2,␣
 ↪random_state=42)

# Create generators
batch_size = 64
train_generator = DataGenerator(X_train, Y_train, batch_size, vocab_size)
val_generator = DataGenerator(X_val, Y_val, batch_size, vocab_size)
X_batch, Y_batch_onehot = train_generator[0]
print("Shape of X_batch:", X_batch.shape)
print("Shape of Y_batch_onehot:", Y_batch_onehot.shape)

# Model construction
```

```
inputs = Input(shape=(X.shape[1],))
x = Embedding(input_dim=vocab_size, output_dim=embedding_size,␣
 ↪mask_zero=True)(inputs)
# x = SimpleRNN(hidden_size, return_sequences=True)(x)
x = SimpleRNN(hidden_size, return_sequences=True, dropout=0.2)(x)
outputs = Dense(vocab_size, activation='softmax')(x)

# Compile the model
model = Model(inputs, outputs)
model.compile(loss='categorical_crossentropy', optimizer=Adam(),␣
 ↪metrics=['accuracy'])
model.summary()

# Train using the generator
history = model.fit(train_generator, validation_data=val_generator, epochs=5)
```

```
Shape of X_batch: (64, 48)
Shape of Y_batch_onehot: (64, 48, 2843)
Model: "model"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_1 (InputLayer)        [(None, 48)]              0

 embedding (Embedding)       (None, 48, 64)            181952

 simple_rnn (SimpleRNN)      (None, 48, 128)           24704

 dense (Dense)               (None, 48, 2843)          366747

=================================================================
Total params: 573403 (2.19 MB)
Trainable params: 573403 (2.19 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
Epoch 1/5
2180/2180 [==============================] - 192s 87ms/step - loss: 0.6064 -
accuracy: 0.9906 - val_loss: 0.3764 - val_accuracy: 0.9904
Epoch 2/5
2180/2180 [==============================] - 174s 80ms/step - loss: 0.3592 -
accuracy: 0.9906 - val_loss: 0.3813 - val_accuracy: 0.9904
Epoch 3/5
2180/2180 [==============================] - 173s 79ms/step - loss: 0.3678 -
accuracy: 0.9906 - val_loss: 0.3837 - val_accuracy: 0.9904
Epoch 4/5
2180/2180 [==============================] - 176s 81ms/step - loss: 0.3692 -
accuracy: 0.9906 - val_loss: 0.3988 - val_accuracy: 0.9904
```

```
Epoch 5/5
2180/2180 [==============================] - 173s 79ms/step - loss: 0.3702 -
accuracy: 0.9906 - val_loss: 0.3795 - val_accuracy: 0.9904
```

[24]:
```
from collections import Counter
print("Training label distribution:", Counter(Y_train.flatten()))
print("Validation label distribution:", Counter(Y_val.flatten()))
```

```
Training label distribution: Counter({0: 6530084, 1: 23, 2: 12, 4: 9, 5: 8, 3:
8, 6: 7, 8: 6, 10: 6, 9: 4, 23: 4, 24: 4, 25: 4, 26: 4, 14: 4, 12: 4, 7: 4, 75:
3, 68: 3, 69: 3, 70: 3, 131: 3, 132: 3, 95: 3, 45: 3, 113: 3, 18: 3, 183: 3,
168: 3, 135: 3, 136: 3, 137: 3, 77: 3, 78: 3, 79: 3, 51: 3, 108: 3, 109: 3, 110:
3, 138: 3, 49: 3, 28: 3, 29: 3, 30: 3, 151: 3, 152: 3, 153: 3, 154: 3, 172: 3,
173: 3, 174: 3, 50: 3, 31: 3, 32: 3, 33: 3, 91: 3, 126: 3, 19: 3, 20: 3, 21: 3,
37: 3, 122: 3, 115: 3, 177: 3, 178: 3, 179: 3, 180: 3, 54: 3, 55: 3, 81: 3, 53:
3, 155: 3, 156: 3, 3966: 2, 4221: 2, 1946: 2, 59: 2, 4121: 2, 362: 2, 3277: 2,
3158: 2, 2831: 2, 2832: 2, 2833: 2, 3118: 2, 4650: 2, 1281: 2, 1864: 2, 1865: 2,
1866: 2, 4555: 2, 2973: 2, 2974: 2, 4587: 2, 4588: 2, 4589: 2, 1051: 2, 3447: 2,
3448: 2, 3449: 2, 4460: 2, 332: 2, 3854: 2, 2508: 2, 2509: 2, 2781: 2, 4571: 2,
4572: 2, 4573: 2, 1483: 2, 4244: 2, 1724: 2, 1725: 2, 1726: 2, 2480: 2, 2984: 2,
2494: 2, 3029: 2, 3030: 2, 3031: 2, 1746: 2, 1747: 2, 1748: 2, 1749: 2, 3989: 2,
2545: 2, 2546: 2, 4297: 2, 4518: 2, 4519: 2, 4520: 2, 4521: 2, 3330: 2, 2808: 2,
2809: 2, 2810: 2, 3725: 2, 3726: 2, 3727: 2, 905: 2, 906: 2, 907: 2, 3809: 2,
3810: 2, 3811: 2, 3812: 2, 3813: 2, 3814: 2, 1326: 2, 1327: 2, 1328: 2, 2812: 2,
2813: 2, 2814: 2, 4282: 2, 4685: 2, 4686: 2, 1674: 2, 1367: 2, 1368: 2, 1369: 2,
1668: 2, 1669: 2, 1670: 2, 1671: 2, 1672: 2, 611: 2, 1721: 2, 2455: 2, 2236: 2,
1651: 2, 1652: 2, 1653: 2, 3827: 2, 2192: 2, 438: 2, 1965: 2, 417: 2, 418: 2,
419: 2, 3667: 2, 4840: 2, 983: 2, 2939: 2, 1200: 2, 1201: 2, 1202: 2, 3502: 2,
1741: 2, 4781: 2, 4782: 2, 4783: 2, 140: 2, 2756: 2, 1491: 2, 1492: 2, 1493: 2,
624: 2, 3825: 2, 2697: 2, 2698: 2, 2699: 2, 3597: 2, 3598: 2, 3599: 2, 1537: 2,
482: 2, 4140: 2, 4141: 2, 4142: 2, 2298: 2, 4350: 2, 1409: 2, 1462: 2, 3903: 2,
3904: 2, 3905: 2, 945: 2, 946: 2, 947: 2, 3089: 2, 2107: 2, 3223: 2, 1073: 2,
86: 2, 87: 2, 2867: 2, 606: 2, 1029: 2, 1030: 2, 1031: 2, 463: 2, 3156: 2, 4613:
2, 4614: 2, 4615: 2, 1140: 2, 4593: 2, 3137: 2, 3138: 2, 4258: 2, 2515: 2, 1988:
2, 510: 2, 1100: 2, 634: 2, 3978: 2, 3979: 2, 3980: 2, 1872: 2, 834: 2, 2398: 2,
3910: 2, 3911: 2, 4108: 2, 4432: 2, 4433: 2, 2206: 2, 2207: 2, 230: 2, 1474: 2,
1475: 2, 1476: 2, 771: 2, 116: 2, 967: 2, 968: 2, 969: 2, 4208: 2, 4209: 2,
4210: 2, 3052: 2, 3053: 2, 3054: 2, 2089: 2, 2090: 2, 2091: 2, 3720: 2, 571: 2,
3643: 2, 219: 2, 220: 2, 221: 2, 767: 2, 4643: 2, 1874: 2, 1875: 2, 2572: 2,
4791: 2, 4792: 2, 1709: 2, 1710: 2, 1711: 2, 1926: 2, 1927: 2, 1928: 2, 1041: 2,
1151: 2, 1773: 2, 2227: 2, 2650: 2, 2651: 2, 2652: 2, 4524: 2, 4525: 2, 4526: 2,
1657: 2, 1244: 2, 1245: 2, 1246: 2, 1247: 2, 1248: 2, 1249: 2, 4574: 2, 4575: 2,
4576: 2, 2991: 2, 3359: 2, 4528: 2, 1339: 2, 1340: 2, 1341: 2, 3375: 2, 3651: 2,
3652: 2, 3653: 2, 4777: 2, 4778: 2, 4779: 2, 2658: 2, 2225: 2, 398: 2, 4000: 2,
4001: 2, 4583: 2, 4584: 2, 4585: 2, 2622: 2, 2623: 2, 2624: 2, 1841: 2, 1842: 2,
2919: 2, 4053: 2, 1292: 2, 1293: 2, 1294: 2, 1295: 2, 2421: 2, 2422: 2, 2423: 2,
3894: 2, 3895: 2, 3896: 2, 3897: 2, 3898: 2, 384: 2, 2929: 2, 2930: 2, 161: 2,
162: 2, 163: 2, 314: 2, 2522: 2, 4078: 2, 4079: 2, 3680: 2, 3681: 2, 3227: 2,
```

```
288080: 1, 105677: 1, 105678: 1, 105679: 1, 105680: 1, 105681: 1, 105682: 1,
278469: 1, 278470: 1, 205427: 1, 290578: 1, 290579: 1, 290580: 1, 226983: 1,
166925: 1, 166926: 1, 166927: 1, 169389: 1, 376109: 1, 272034: 1, 324316: 1,
268436: 1, 268437: 1, 268438: 1, 107522: 1, 73523: 1, 73524: 1, 73525: 1,
294188: 1, 294189: 1, 294190: 1, 10455: 1, 215927: 1, 13692: 1, 13693: 1, 13694:
1, 340325: 1, 340326: 1, 340327: 1, 118091: 1, 118092: 1, 118093: 1, 78692: 1,
54887: 1, 54888: 1, 54889: 1, 269552: 1, 128806: 1, 231513: 1, 231514: 1,
151242: 1, 327527: 1, 327528: 1, 327529: 1, 333816: 1, 333817: 1, 115158: 1,
103969: 1, 6981: 1, 6982: 1, 6983: 1, 155495: 1, 155496: 1, 155497: 1, 376552:
1, 376553: 1, 376554: 1, 37021: 1, 275152: 1, 275153: 1, 275154: 1, 350830: 1,
67200: 1, 183602: 1, 251876: 1, 251877: 1, 251878: 1, 251879: 1, 251880: 1,
251881: 1, 368522: 1, 368523: 1, 368524: 1, 358468: 1, 358469: 1, 358470: 1,
241443: 1, 237270: 1, 357836: 1, 294048: 1, 12327: 1, 295322: 1, 107166: 1,
107167: 1, 127309: 1, 127310: 1, 200937: 1})
```

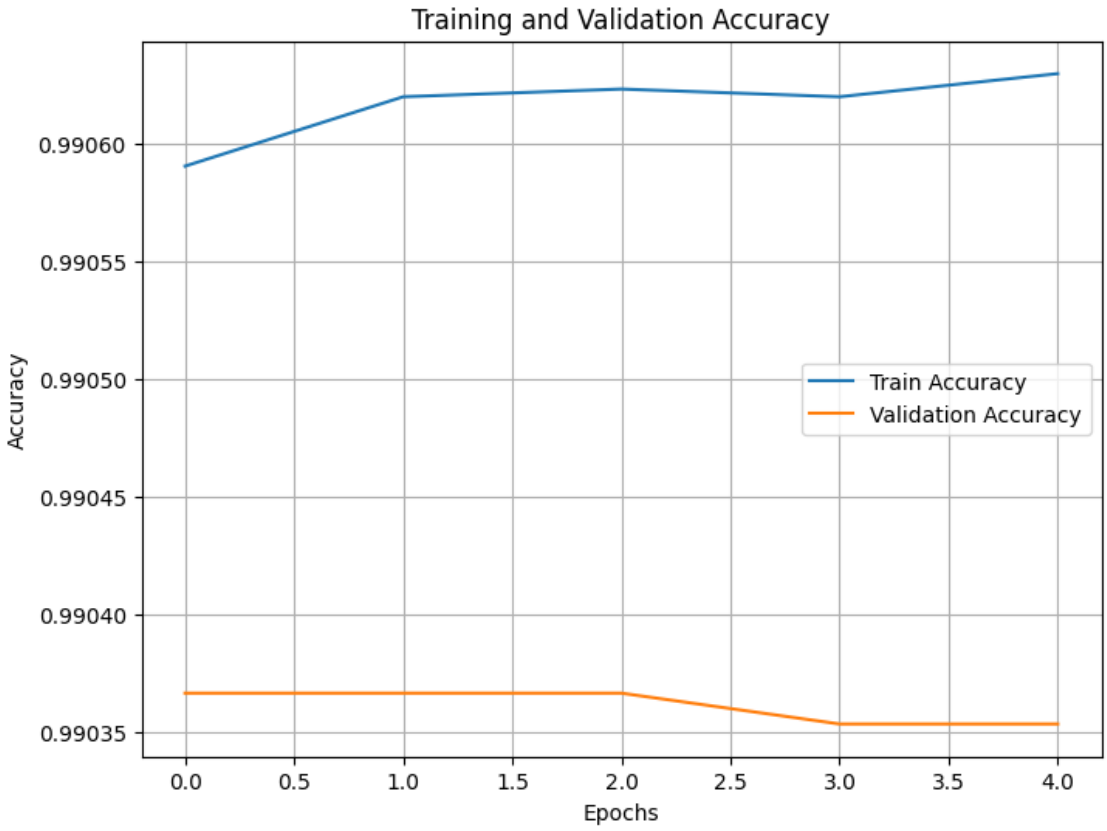
[25]:
```
print("Y_batch_onehot shape:", Y_batch_onehot.shape)
print("Number of unique labels:", len(set(Y.flatten())))
```

```
Y_batch_onehot shape: (64, 48, 2843)
Number of unique labels: 204266
```

[26]:
```
print("Training Set Shape:", X_train.shape, Y_train.shape)
print("Validation Set Shape:", X_val.shape, Y_val.shape)
```

```
Training Set Shape: (139496, 48) (139496, 48)
Validation Set Shape: (34875, 48) (34875, 48)
```

[27]:
```
plt.figure(figsize=(8, 6))
plt.plot(history.history['accuracy'], label='Train Accuracy')
plt.plot(history.history['val_accuracy'], label='Validation Accuracy')
plt.title('Training and Validation Accuracy')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()
plt.grid(True)
plt.show()
```



[28]:
```
# from collections import Counter
# print("Training Set Label Distribution:", Counter(Y_train.flatten()))
# print("Validation Set Label Distribution:", Counter(Y_val.flatten()))
```

0.5 STEP 3: LSTM

[29]:
```
K.clear_session()
tf.config.experimental.reset_memory_stats('/GPU:0')
```

[30]:
```
from tensorflow.keras.layers import Bidirectional, Attention
max_len = 49
# vocab_size = 5000

class DataGenerator(Sequence):
    def __init__(self, X, Y, batch_size, max_len):
        self.X = X
        self.Y = Y
        self.batch_size = batch_size
        self.max_len = max_len
        self.indices = np.arange(len(self.X))
```

```
    def __len__(self):
        return int(np.ceil(len(self.X) / self.batch_size))

    def __getitem__(self, index):
        start = index * self.batch_size
        end = start + self.batch_size
        batch_indices = self.indices[start:end].astype(int)

        X_batch = [self.X[i] for i in batch_indices]
        Y_batch = [self.Y[i] for i in batch_indices]

        X_batch = pad_sequences(X_batch, maxlen=self.max_len, padding='post')
        Y_batch = pad_sequences(Y_batch, maxlen=self.max_len, padding='post')

        return np.array(X_batch), np.array(Y_batch)

    def on_epoch_end(self):
        np.random.shuffle(self.indices)


X_train, X_val, Y_train, Y_val = train_test_split(X, Y, test_size=0.2,␣
 ↪random_state=42)

# Generator configuration
batch_size = 128
train_generator = DataGenerator(X_train, Y_train, batch_size, max_len)
val_generator = DataGenerator(X_val, Y_val, batch_size, max_len)

# Model construction
embedding_size = 128 # Embedding layer dimension
hidden_size1 = 128  # Hidden layer size for the first LSTM
hidden_size2 = 64   # Hidden layer size for the second LSTM

inp = Input(shape=(max_len,))
x = Embedding(input_dim=vocab_size, output_dim=embedding_size,␣
 ↪mask_zero=True)(inp)
x = LSTM(hidden_size1, return_sequences=True)(x)
x = Dropout(0.2)(x)
x = Bidirectional(LSTM(hidden_size2, return_sequences=True))(x)
outputs = Dense(vocab_size, activation='softmax')(x)

model = Model(inputs=inp, outputs=outputs)


# Define the model
# model = Model(inputs=inp, outputs=outputs)
```

```
# Compile the model
model.compile(loss='sparse_categorical_crossentropy',
              optimizer=Adam(learning_rate=0.01),
              metrics=['accuracy'])

model.summary()

model.fit(train_generator, validation_data=val_generator, epochs=5)
```

```
Model: "model"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_1 (InputLayer)        [(None, 49)]              0

 embedding (Embedding)       (None, 49, 128)           363904

 lstm (LSTM)                 (None, 49, 128)           131584

 dropout (Dropout)           (None, 49, 128)           0

 bidirectional (Bidirection  (None, 49, 128)           98816
 al)

 dense (Dense)               (None, 49, 2843)          366747

=================================================================
Total params: 961051 (3.67 MB)
Trainable params: 961051 (3.67 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
Epoch 1/5
2024-12-09 22:08:13.379547: W
tensorflow/core/common_runtime/type_inference.cc:339] Type inference failed.
This indicates an invalid graph that escaped type checking. Error message:
INVALID_ARGUMENT: expected compatible input types, but input 1:
type_id: TFT_OPTIONAL
args {
  type_id: TFT_PRODUCT
  args {
    type_id: TFT_TENSOR
    args {
      type_id: TFT_INT32
    }
  }
}
```

```
 is neither a subtype nor a supertype of the combined inputs preceding it:
type_id: TFT_OPTIONAL
args {
  type_id: TFT_PRODUCT
  args {
    type_id: TFT_TENSOR
    args {
      type_id: TFT_FLOAT
    }
  }
}

        for Tuple type infernce function 0
        while inferring type of node 'cond_42/output/_24'
1090/1090 [==============================] - 64s 49ms/step - loss: nan -
accuracy: 0.4570 - val_loss: nan - val_accuracy: 0.4559
Epoch 2/5
1090/1090 [==============================] - 30s 27ms/step - loss: nan -
accuracy: 0.4570 - val_loss: nan - val_accuracy: 0.4559
Epoch 3/5
1090/1090 [==============================] - 30s 28ms/step - loss: nan -
accuracy: 0.4570 - val_loss: nan - val_accuracy: 0.4559
Epoch 4/5
1090/1090 [==============================] - 29s 27ms/step - loss: nan -
accuracy: 0.4570 - val_loss: nan - val_accuracy: 0.4559
Epoch 5/5
1090/1090 [==============================] - 29s 26ms/step - loss: nan -
accuracy: 0.4570 - val_loss: nan - val_accuracy: 0.4559
```

[30]:
```
<keras.src.callbacks.History at 0x7f57af2f3970>
```

[31]:
```
poem_incomplete = ' **** **** **** *****'
poem_index = []
poem_text = ''

for i in range(len(poem_incomplete)):
    current_word = poem_incomplete[i]
    if current_word != '*':
        index = tokenizer.word_index.get(current_word, 0)
    else:
        x = np.expand_dims(poem_index, axis=0)
        x = pad_sequences(x, maxlen=max_len, padding='post')
        y = model.predict(x)[0, i]
        y[0] = 0
        index = np.argmax(y)
        current_word = tokenizer.index_word.get(index, '')
```

```
    poem_index.append(index)
    poem_text += current_word

print("Generated poem:")
print(poem_text[:5])
print(poem_text[5:10])
print(poem_text[10:15])
print(poem_text[15:20])
```

```
1/1 [==============================] - 3s 3s/step
1/1 [==============================] - 0s 69ms/step
1/1 [==============================] - 0s 53ms/step
1/1 [==============================] - 0s 71ms/step
1/1 [==============================] - 0s 68ms/step
1/1 [==============================] - 0s 68ms/step
1/1 [==============================] - 0s 69ms/step
1/1 [==============================] - 0s 75ms/step
1/1 [==============================] - 0s 65ms/step
1/1 [==============================] - 0s 68ms/step
1/1 [==============================] - 0s 67ms/step
1/1 [==============================] - 0s 67ms/step
1/1 [==============================] - 0s 66ms/step
1/1 [==============================] - 0s 66ms/step
1/1 [==============================] - 0s 68ms/step
1/1 [==============================] - 0s 67ms/step
1/1 [==============================] - 0s 65ms/step
Generated poem:
```

[ ]:

[ ]:

[ ]: